MUSE Technical Design Review

PSI, 25 July 2012

Backgrounds & Shielding

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Total elastic event rates:

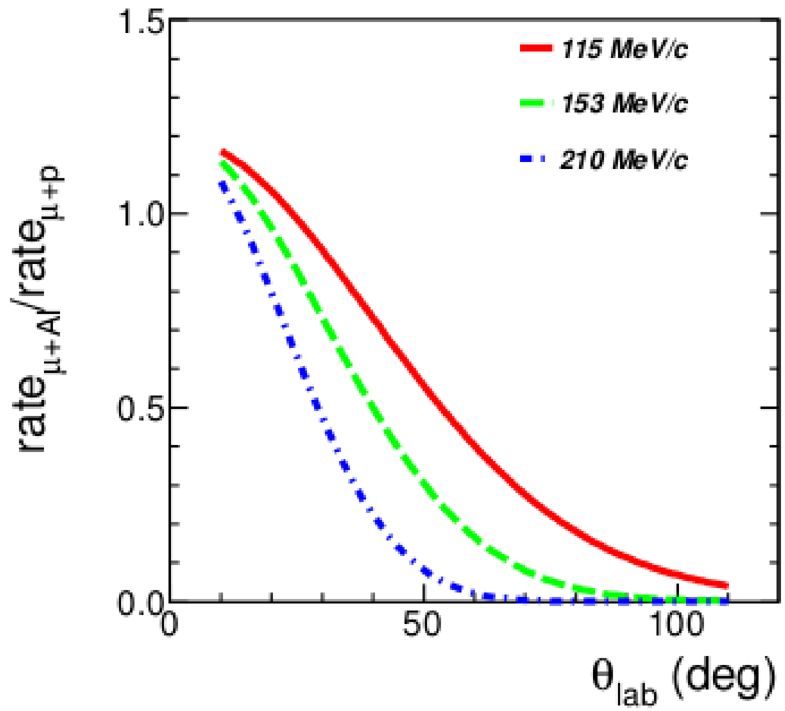
Electrons:	Rate (Hz)
+115 MeV/c	55
+153 MeV/c	22
+210 MeV/c	1.9
-115 MeV/c	55
-153 MeV/c	40
-210 MeV/c	9

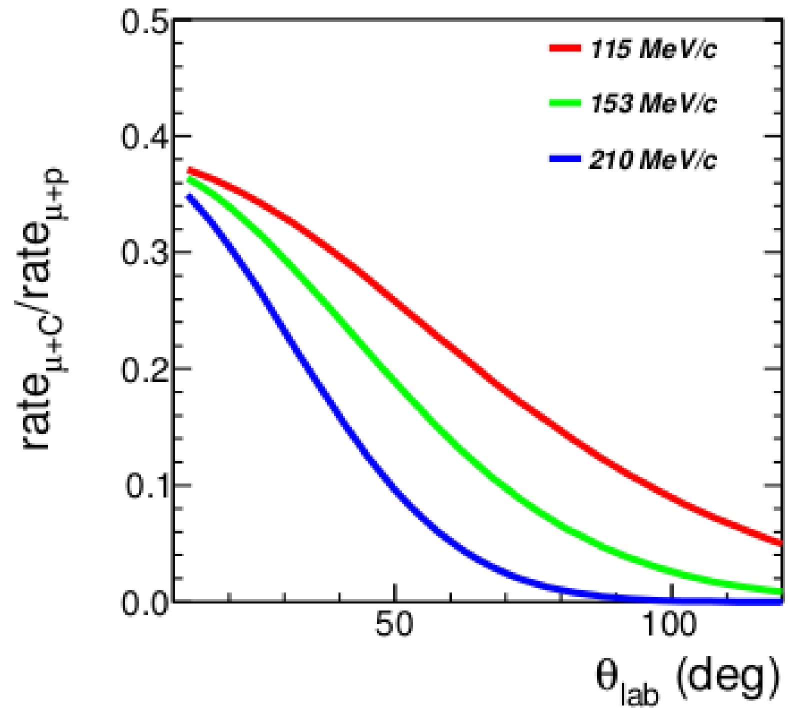
Muons:	Rate (Hz)
+115 MeV/c	17
+153 MeV/c	11
+210 MeV/c	1.7
-115 MeV/c	3.5
-153 MeV/c	3.8
-210 MeV/c	1.4

Target Window Backgrounds:

Ratio of window background rate to elastic μp rate

(Note: these used the old cross section formula for μp scattering, μAl and μC are unchanged, effectively leading to these ratios now being smaller)





Cell window choices:

Aluminum versus Kapton (mostly Carbon)

Based on the size of the cross sections, Kapton is the beneficial choice: 125 microns thick

Target Window Backgrounds:

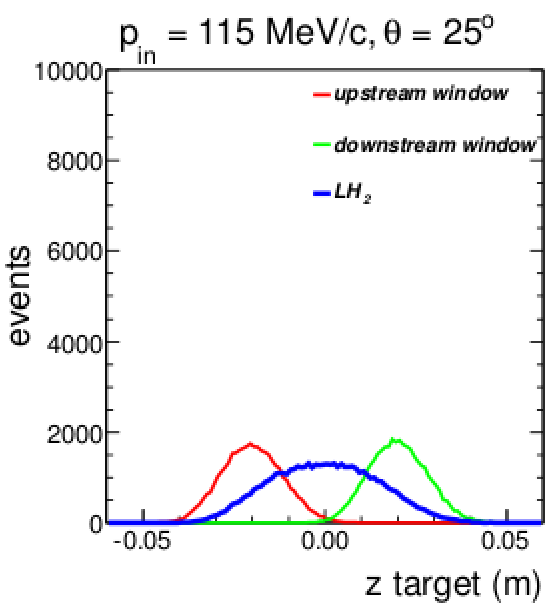
Window background rates (elastic):

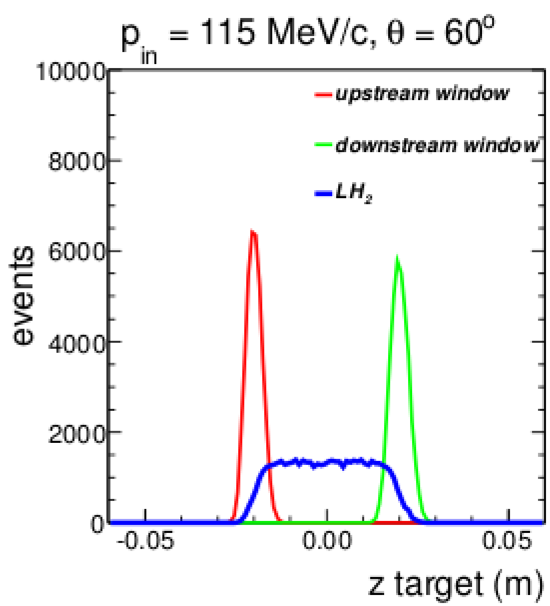
eC: ~3 times smaller than ep, μC: 4-10 times smaller than μp (larger difference at lower momenta)

Other contributions:

→ quasielastic scattering: ~ Z as opposed to Z^2, suppressed
→ pion scattering from windows: order of magnitude smaller than πp events
→ Above additional backgrounds can in principle be simulated with GEANT4, and will be implemented in the future

Empty cell measurements:





→ Resolution poor at forward angles

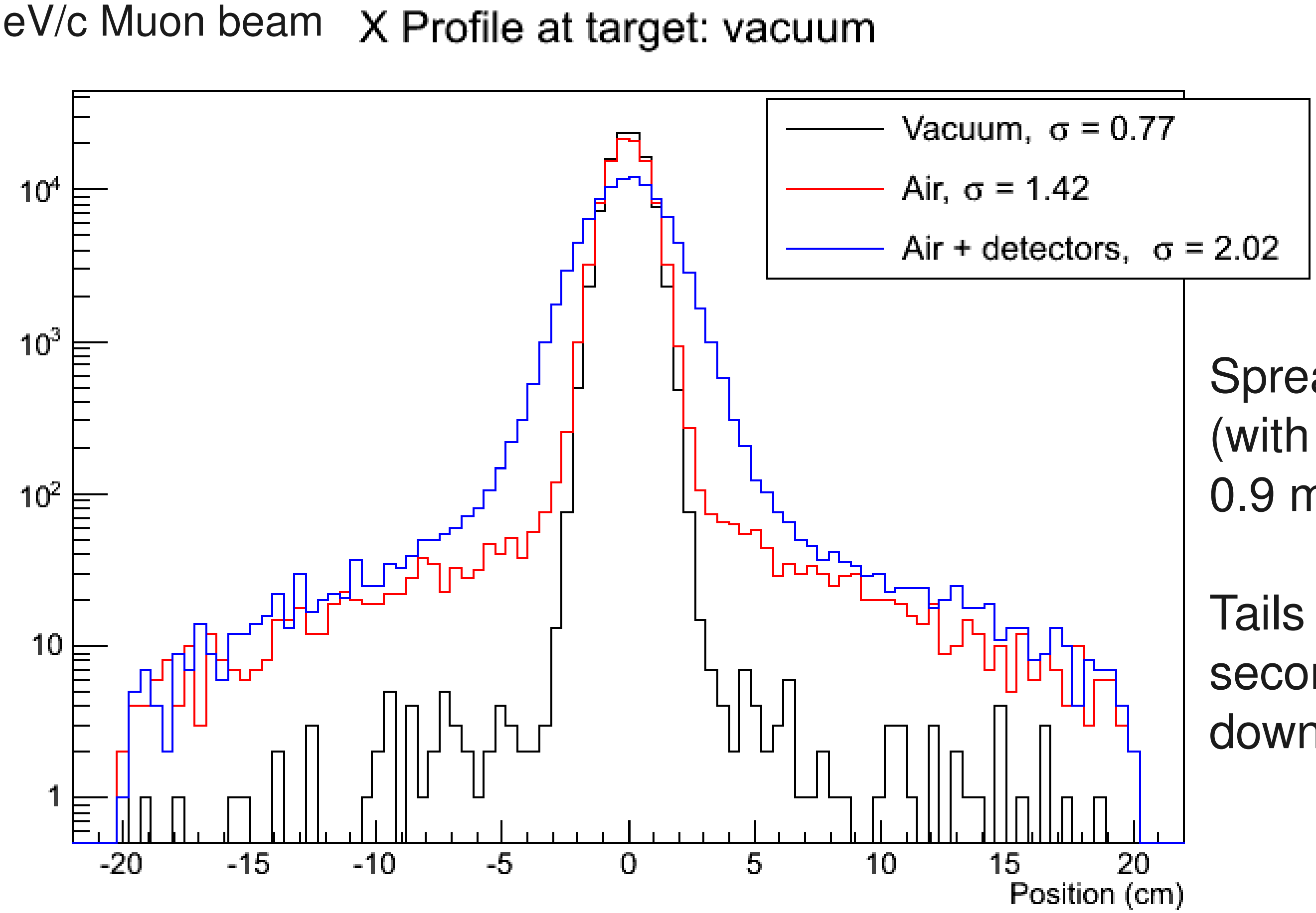
→ Empty cell: dummy foils ~6 times thicker than actual windows (to match radiation length)

→ Spend ~15% of time measuring rates on the empty cell for a subtraction

Beam profile at target:

Beam line ends (after extension) ~0.9 m upstream of the target:

115 MeV/c Muon beam



Spread of a Gaussian thrown beam (with 0.7 cm RMS) traveling the 0.9 m to the target

Tails dominated by low-energy secondary events, but these are down 2-3 orders of magnitude

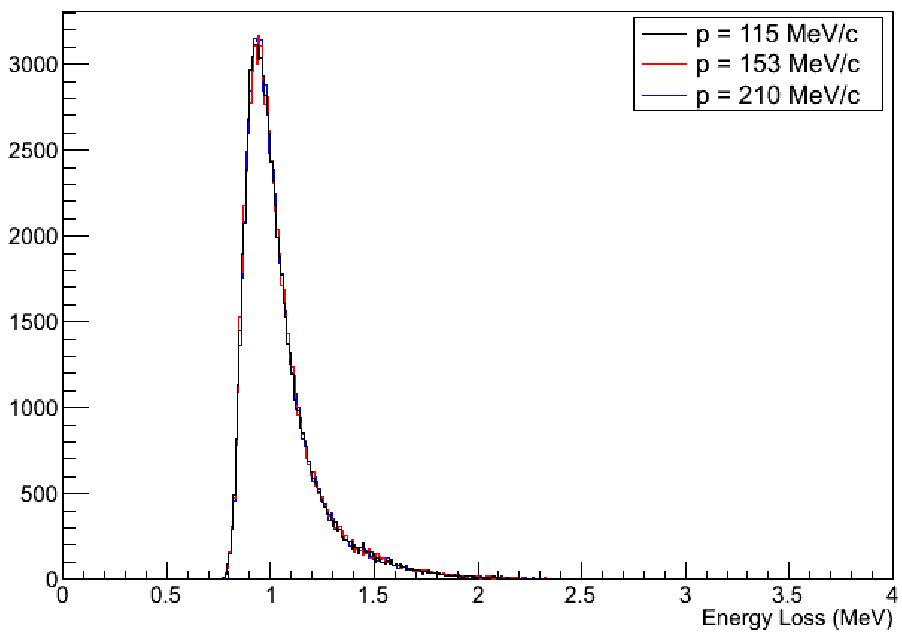
Possible for low-energy tail to interact with unwanted components of the scattering chamber (10-15 x's thicker than the hydrogen)

→ Can place fiducial cuts based on GEM tracks, will study collimation of the beam at the end of the shielding wall or upstream of the scattering chamber to reduce unwanted backgrounds

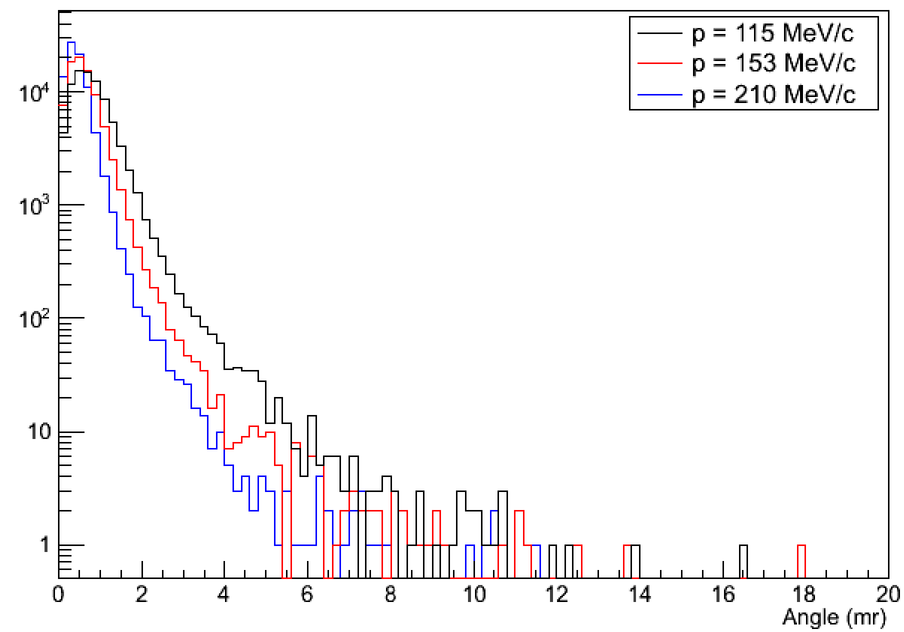
Energy loss/multiple scattering:

GEANT4 simulation of energy loss, multiple scattering for particles traveling through 4 cm LH2 + endcaps

Energy Loss in Target: Electrons



Multiple Scattering in Target: Electrons



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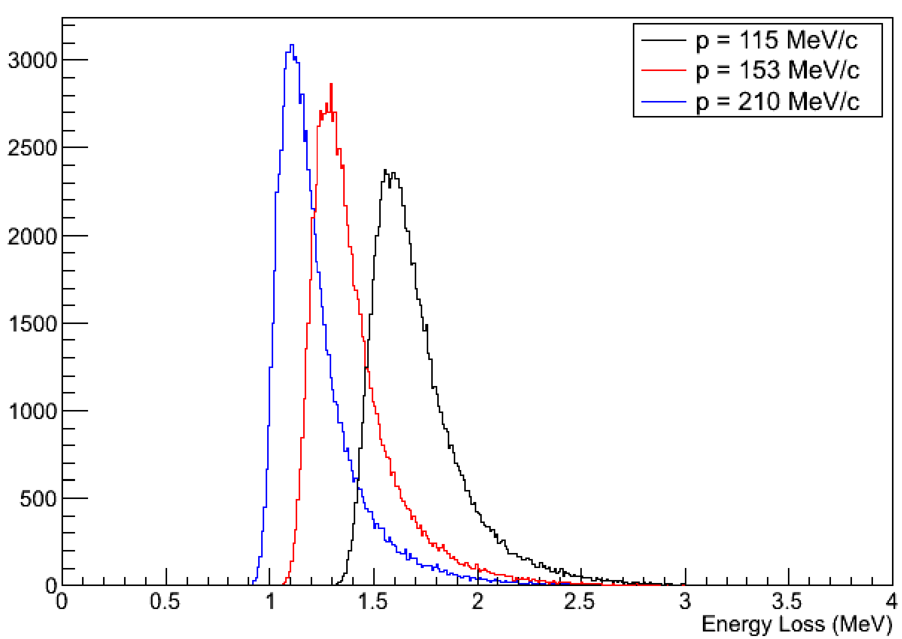

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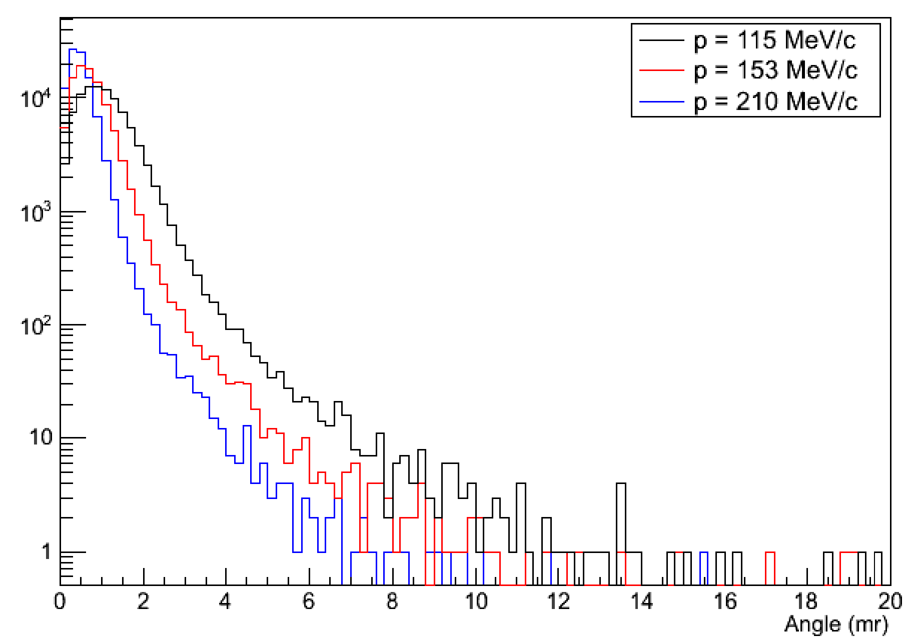
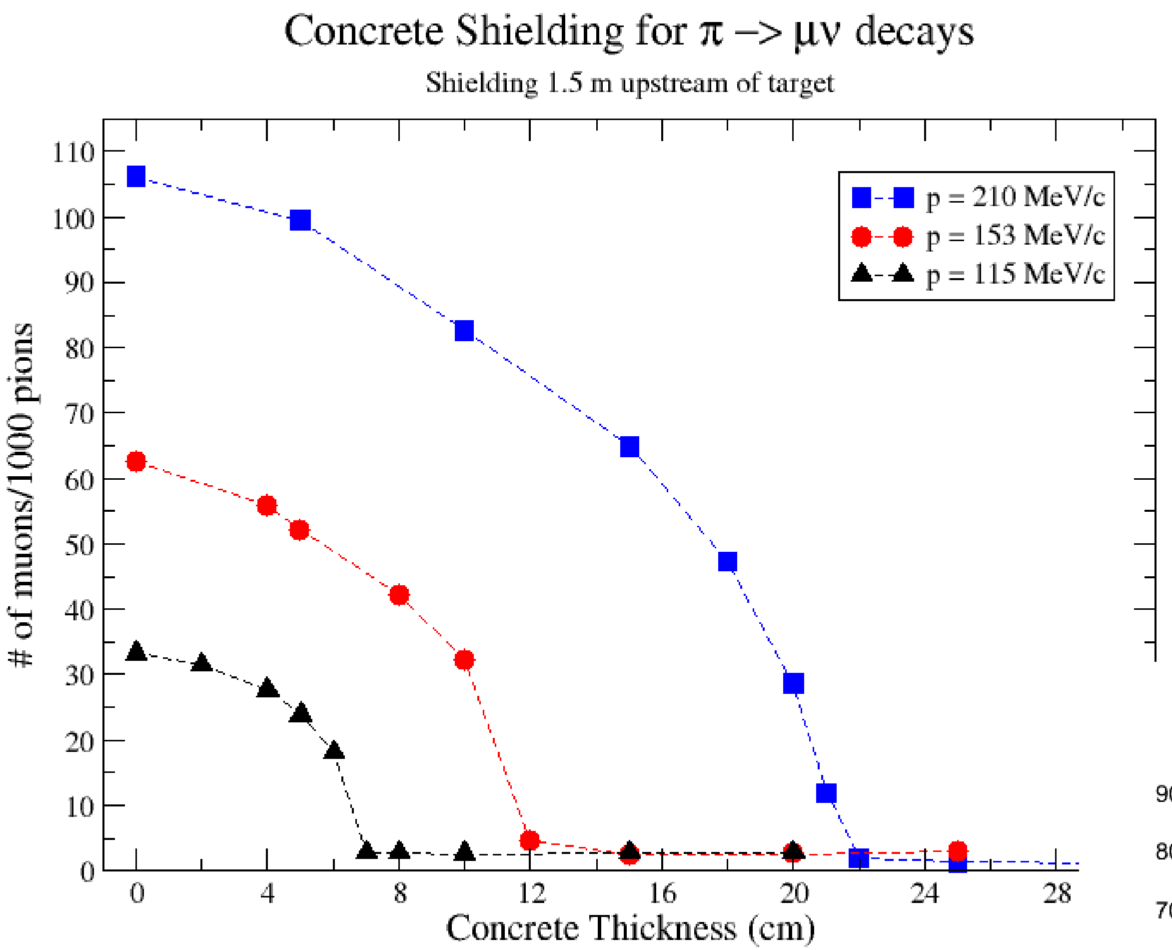
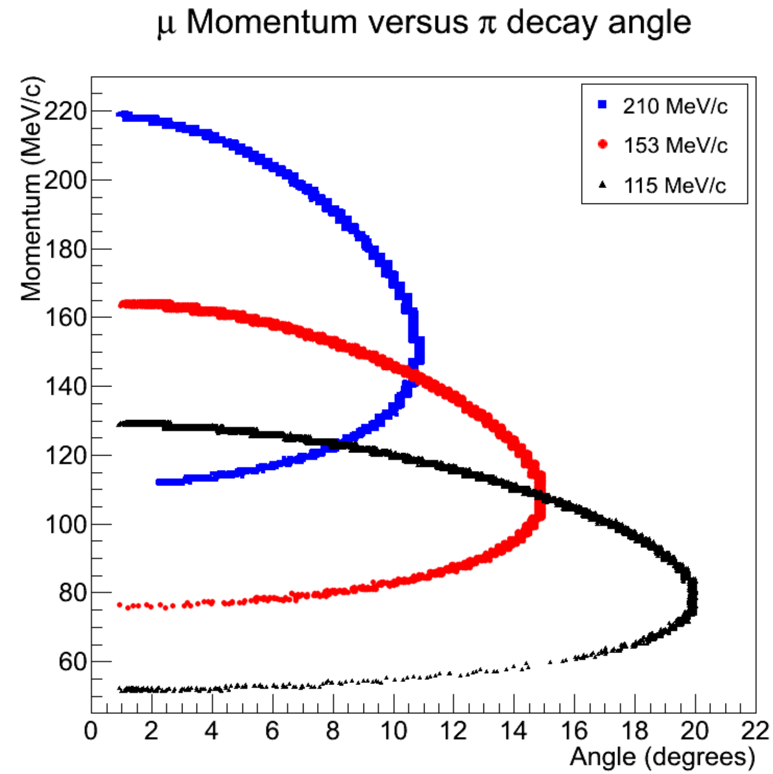
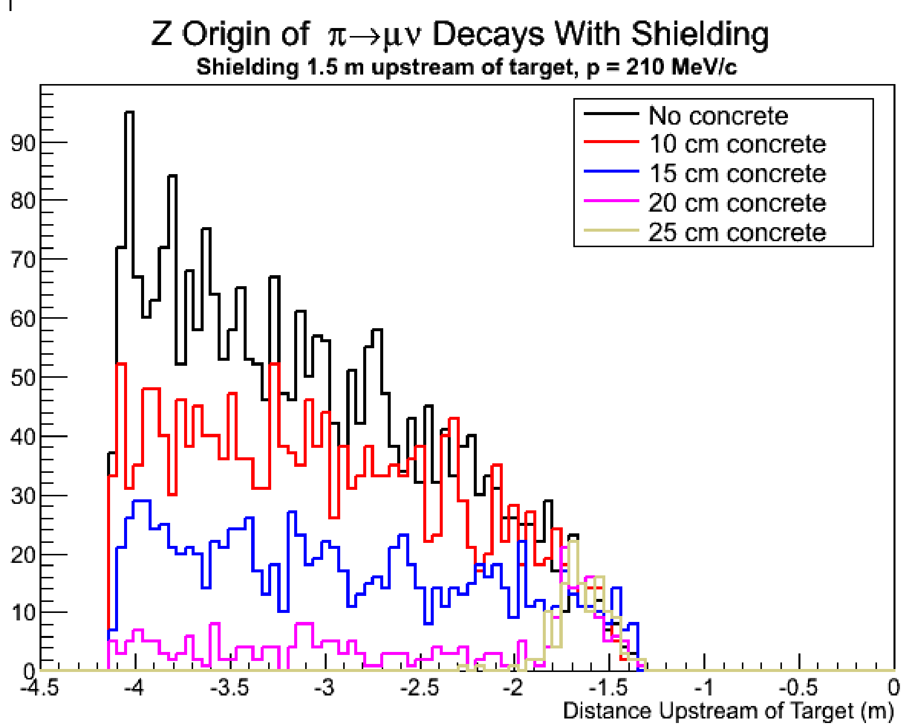


Shielding Simulations: Pion decays:







Left with small, nonzero rate, due to limitation of how close to the target the shielding can be placed

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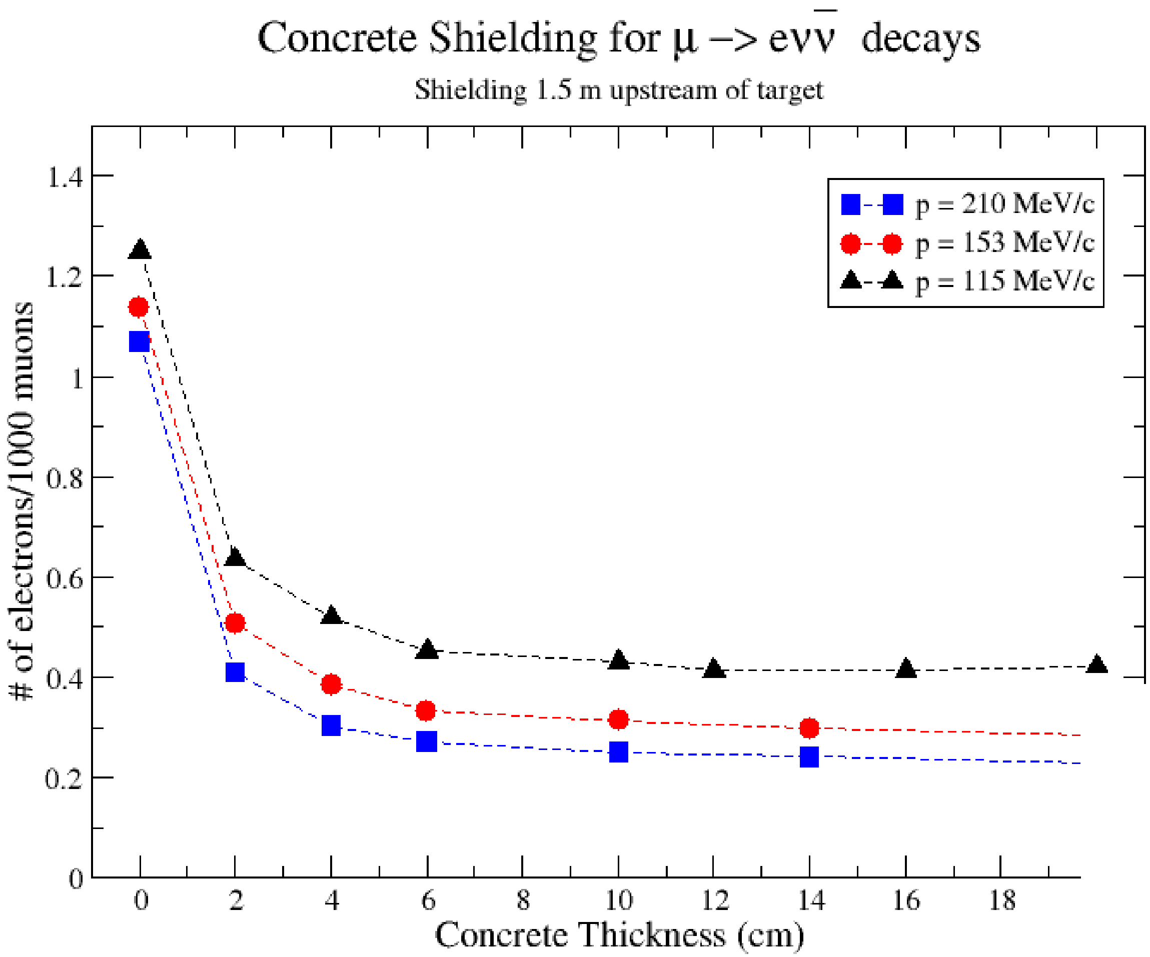
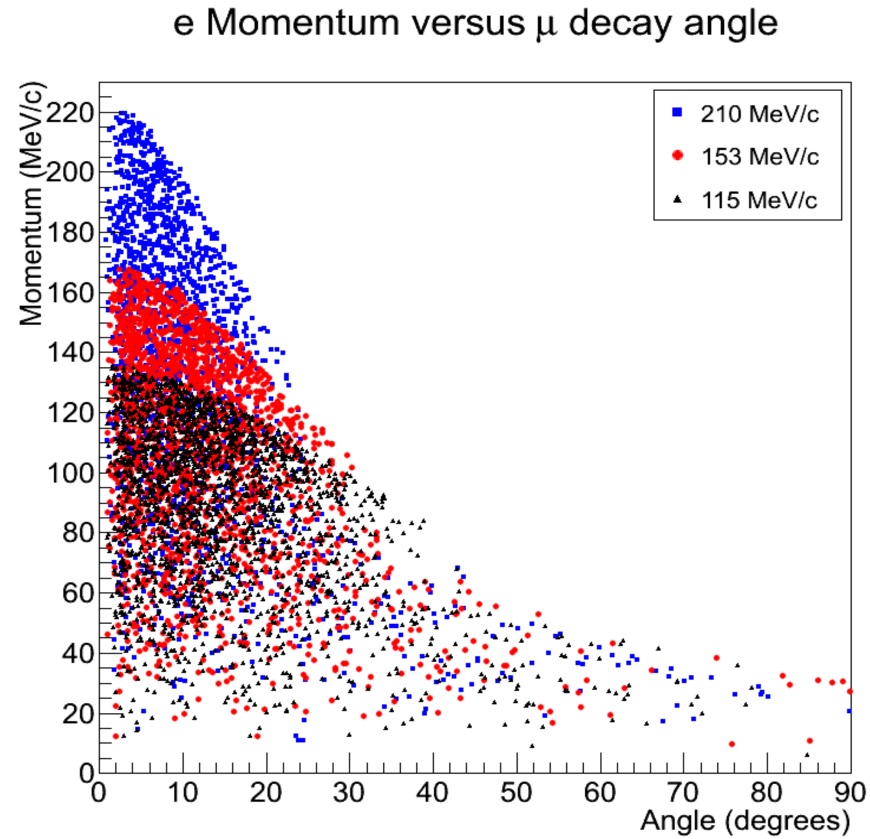
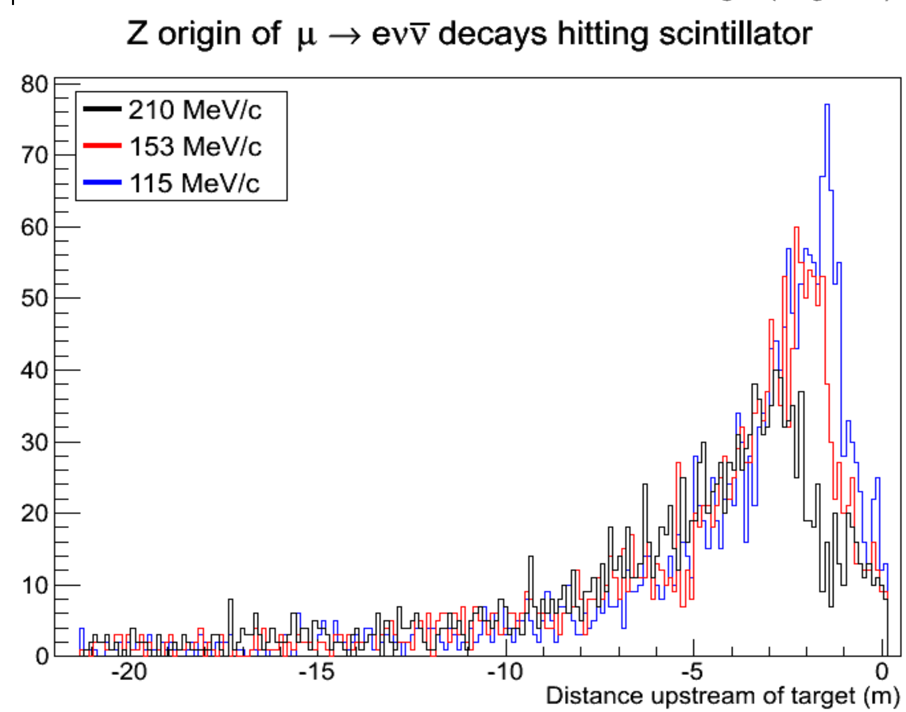




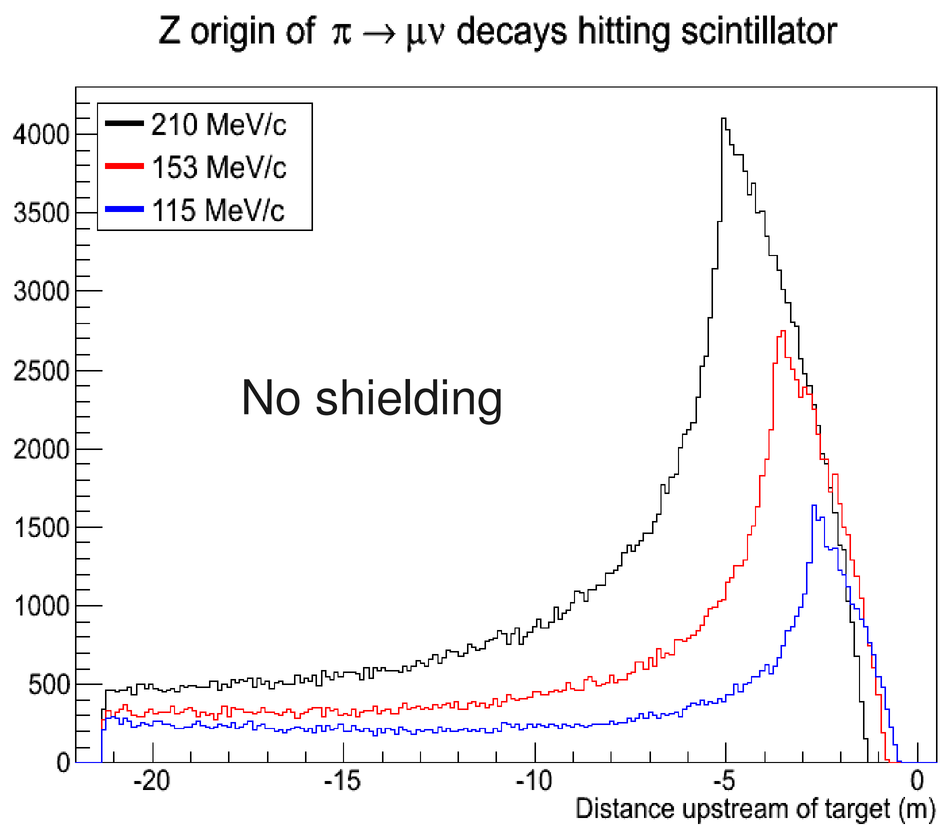


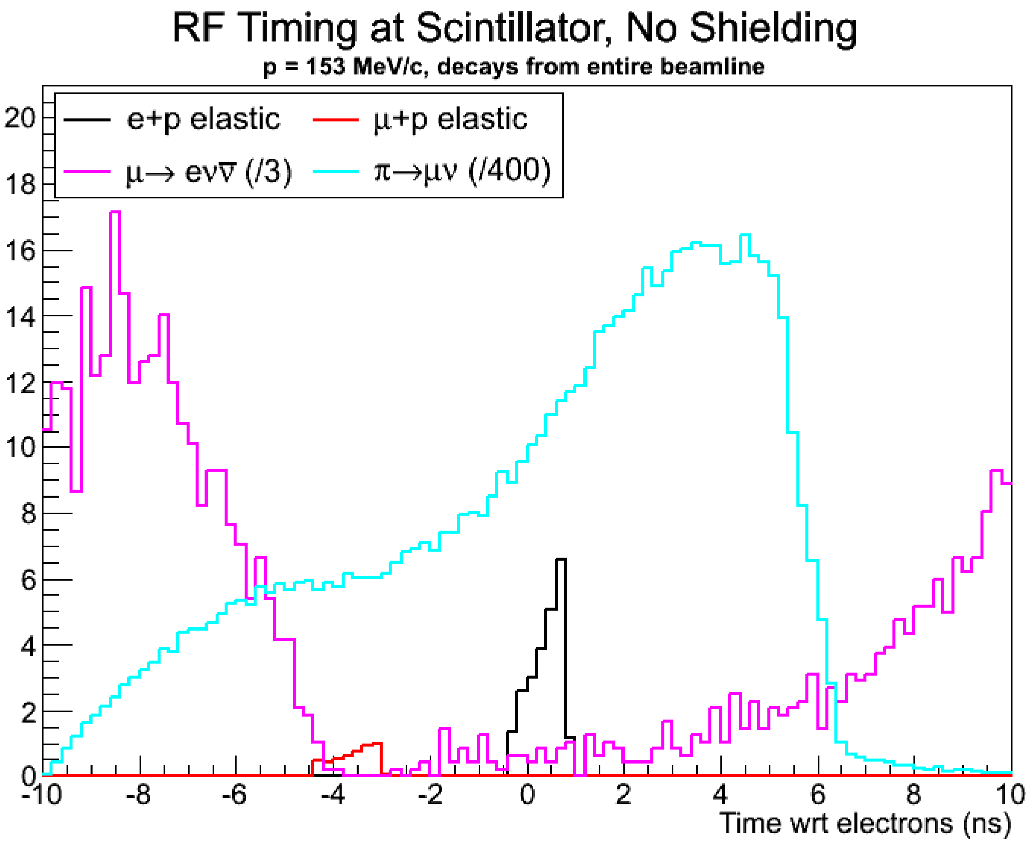
Muon can decay to larger angles, but with low momentum

Z origin of mu decays (right): a small number of μ decays also happen in the target or downstream

Pion Backgrounds:

Pion decays:





With no shielding, flooded with decays coming from far upstream

Tracks won't point back to the target, but can lead to high accidentals rate

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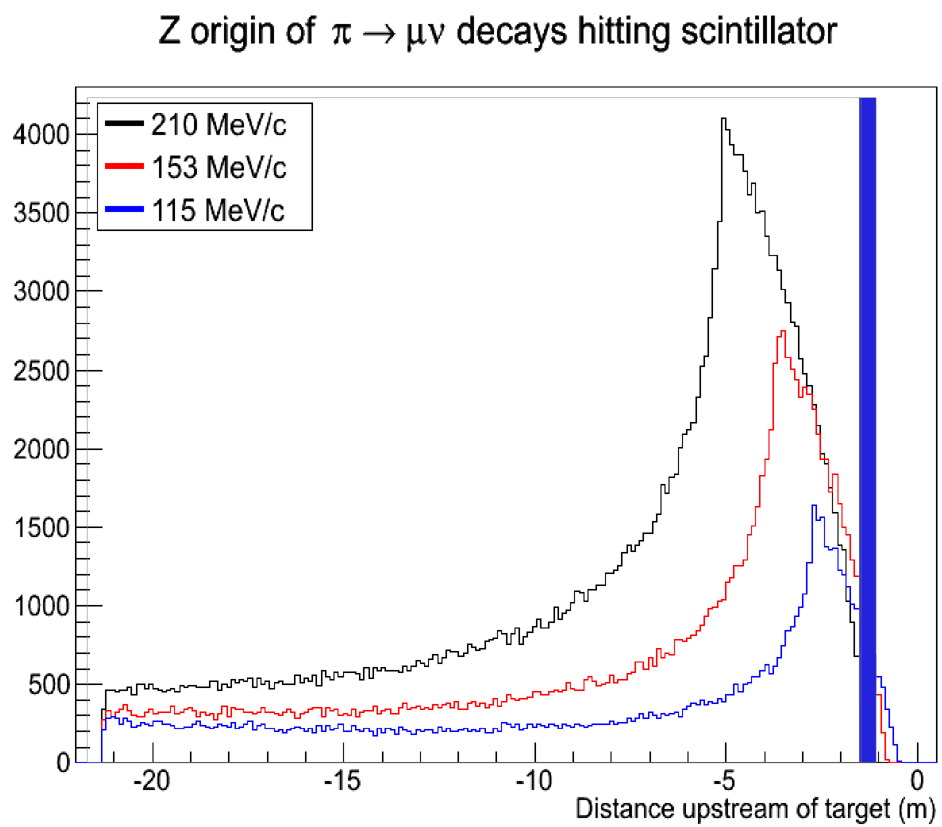

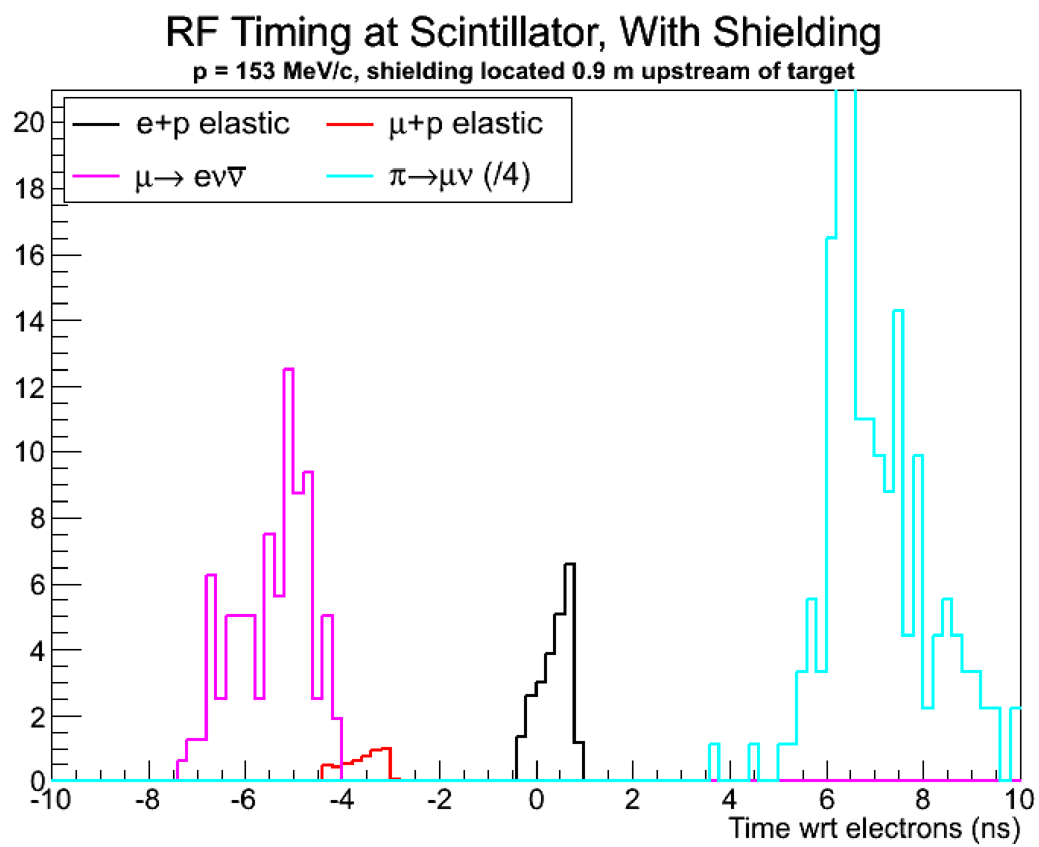

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Tracks won't point back to the target, but can lead to high accidentals rate

Shielding: 50 cm blocks readily available is more than enough to suppress upstream decays

Decay rate greatly reduced, e.g. for 153 MeV/c $\pi+$: 63 kHz → 9 kHz

Backgrounds Overview: Count rate in each wall per 1 MHz beam flux

TABLE I. Table XII of the TDR.

Beam Particle	Beam Momentum (MeV/c)	Front Wall (Hz) 1st bar	Front Wall (Hz) any bar	Back Wall (Hz) 1st bar	Back Wall (Hz) any bar	Coincidence Rate (Hz)
π^+	115	12996	49468	13637	46797	29467
	153	10920	30910	12637	33259	26446
	210	7255	15739	10022	16778	14470
π^-	115	12972	49336	13604	46787	29468
	153	10958	30901	12683	33330	26483
	210	7368	15913	10118	16921	14598
μ^+	115	95	578	137	819	376
	153	66	413	103	578	276
	210	225	933	203	619	195
μ^-	115	102	575	133	802	387
	153	63	410	95	561	280
	210	218	935	197	618	204
e^+	115	1111	4891	794	1533	254
	153	1133	5019	784	1552	260
	210	1162	5148	828	1641	277
e^-	115	1259	5371	918	1770	336
	153	1262	5408	916	1760	324
	210	1232	5389	904	1760	326

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Pion rates: with beam flux estimates, up to ~100 kHz

Reject with beam PID or track projection

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Decays, energy loss in target or air

Møllers/Bhabha, energy loss in target or air

Backgrounds Overview: Count rate in each wall per 1 MHz particle flux

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μ^+	115	376 Hz
	153	414 Hz
	210	123 Hz
μ^-	115	77 Hz
	153	140 Hz
	210	102 Hz
e^+	115	1524 Hz
	153	1144 Hz
	210	205 Hz
e^-	115	2016 Hz
	153	2592 Hz
	210	1141 Hz

The coincidence rates in terms of expected beam flux (per wall):

Pion rates: with beam flux estimates, up to ~100 kHz

Reject with beam PID or track projection

Decays, energy loss in target or air

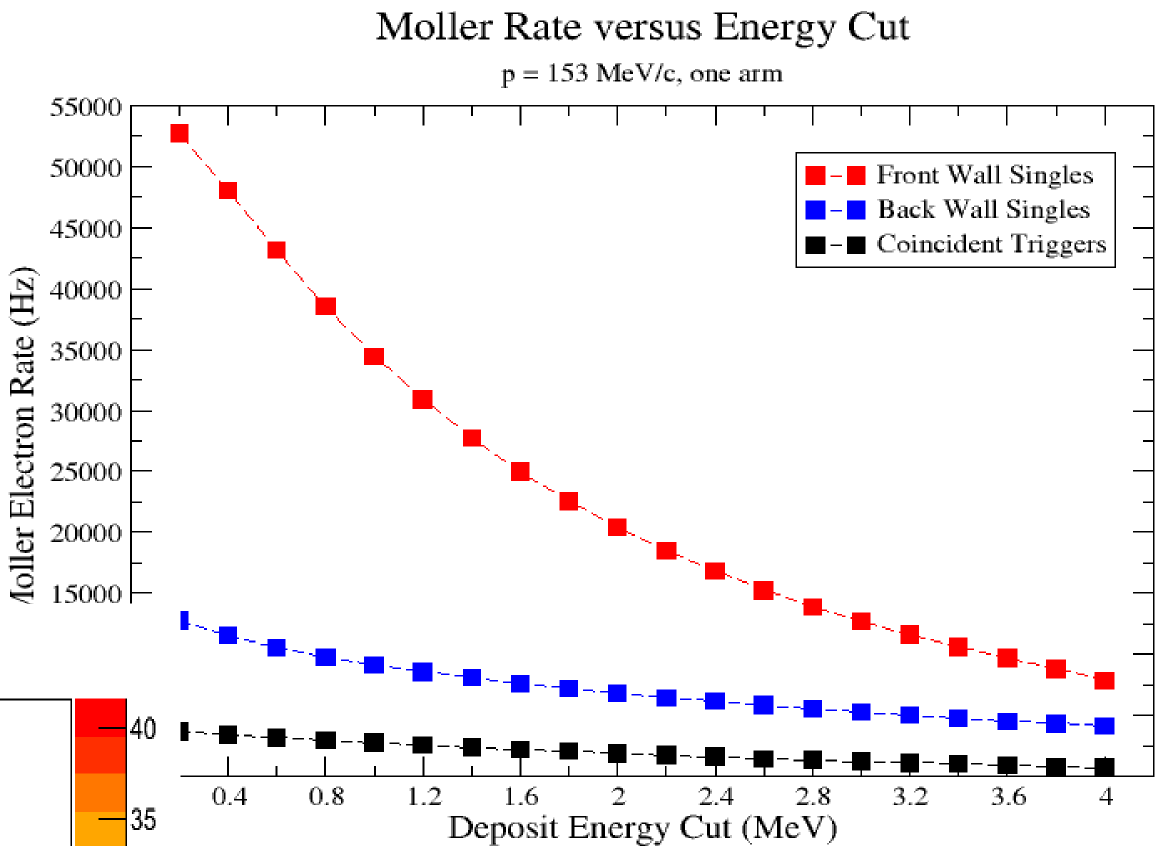
Møllers/Bhabha, energy loss in target or air

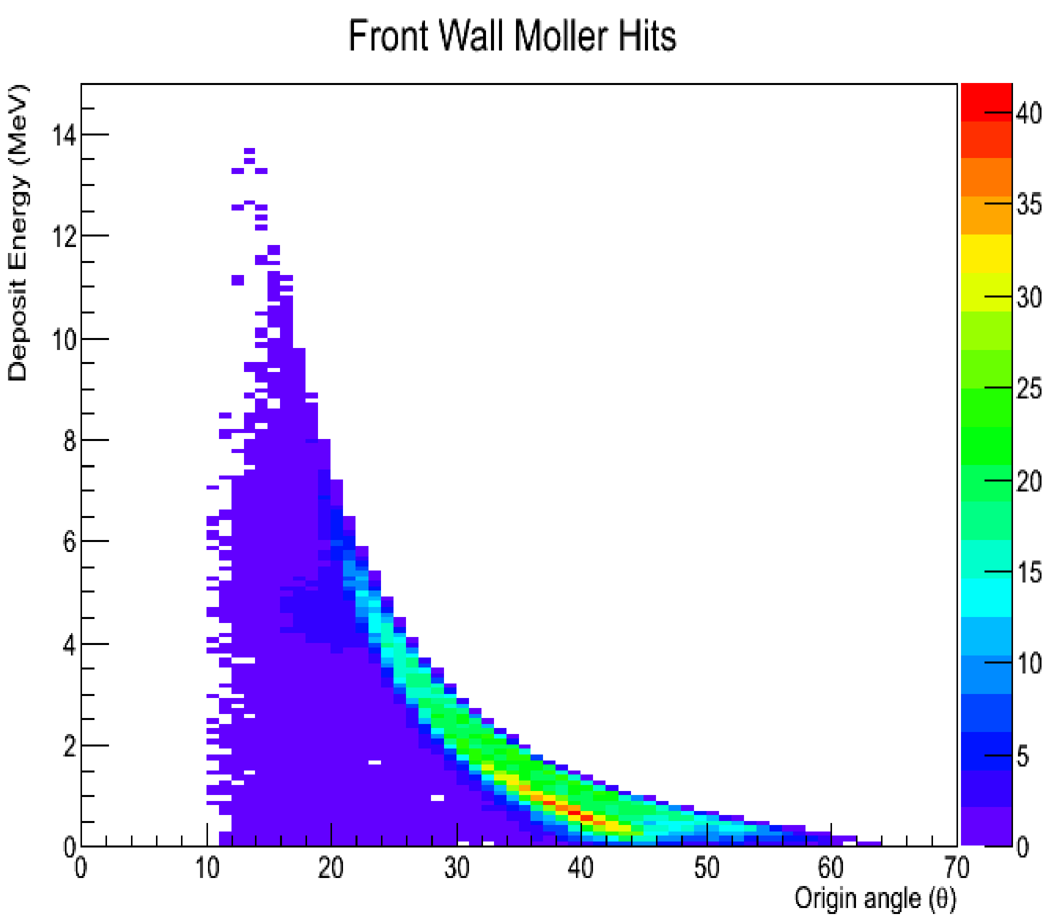
Electron Backgrounds:

e.g. Møller backgrouds:

~70-80% of electron-induced backgrounds pointing to target come from Møller scattering

(Note: scattering chamber not included)





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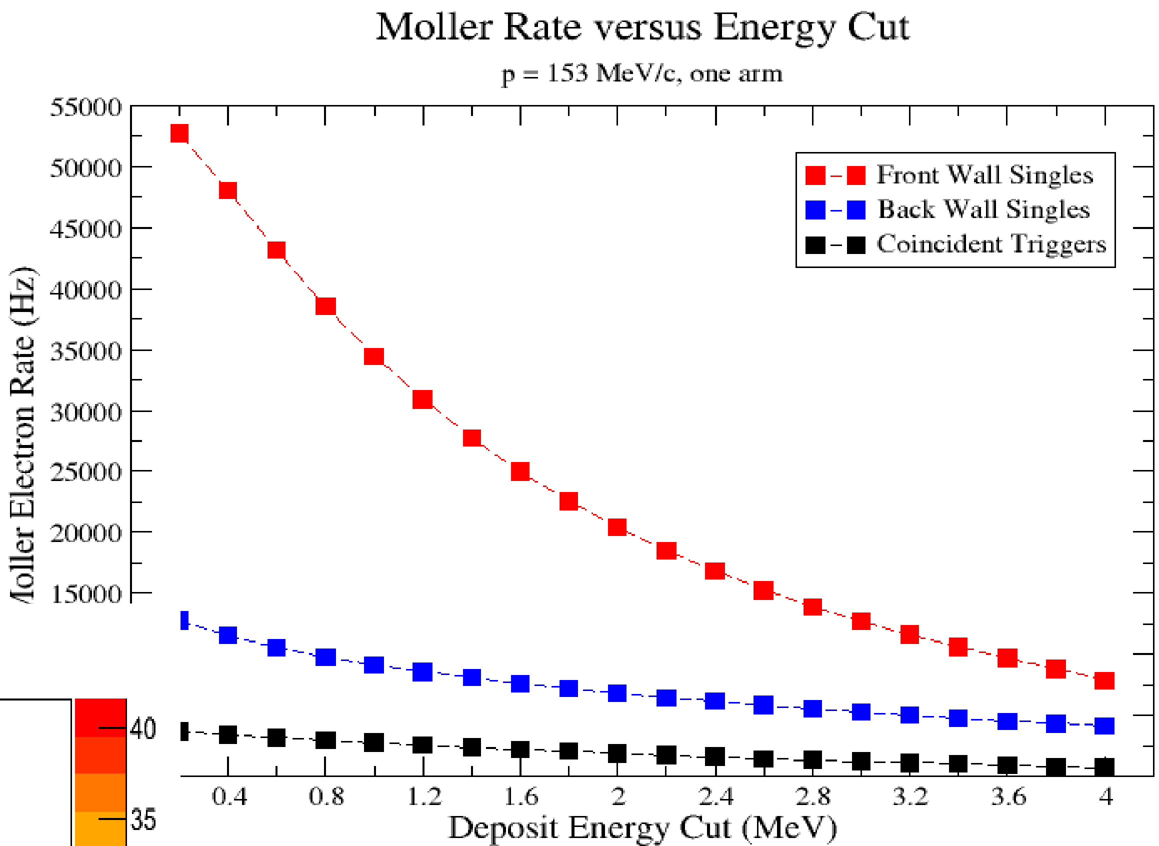

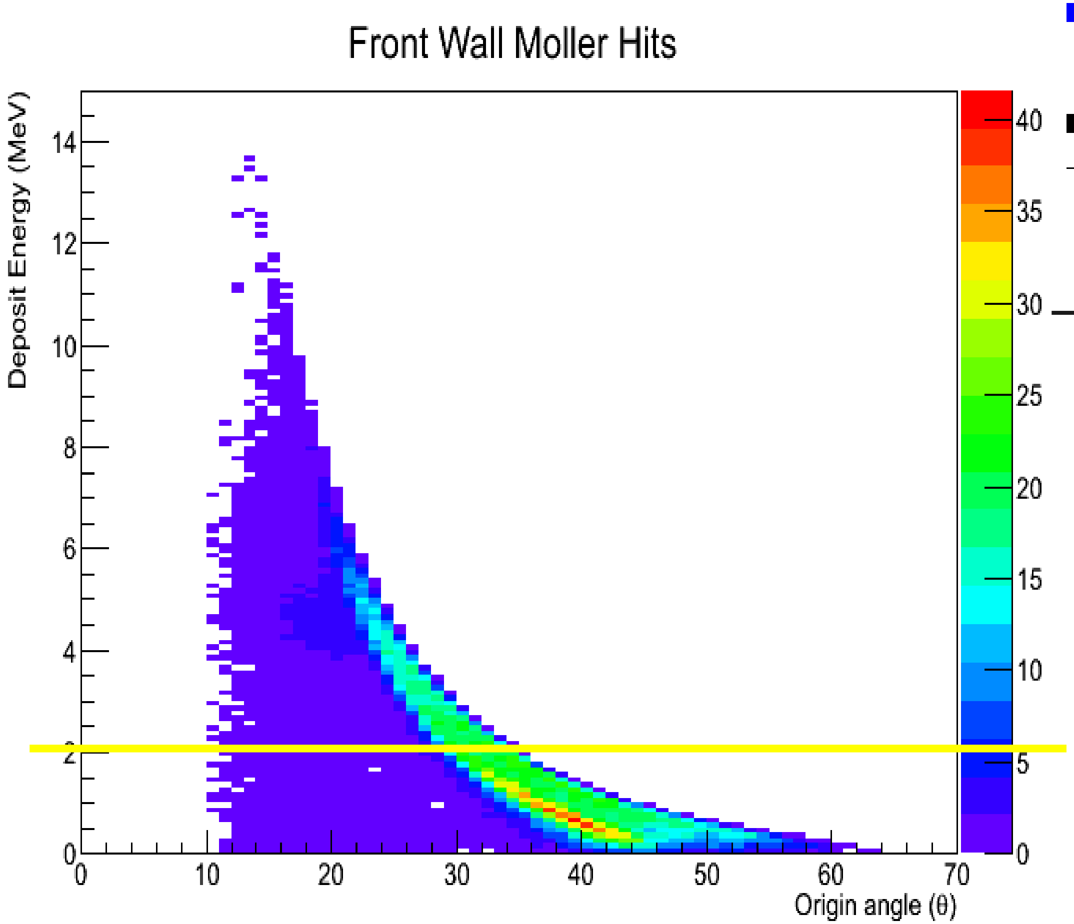

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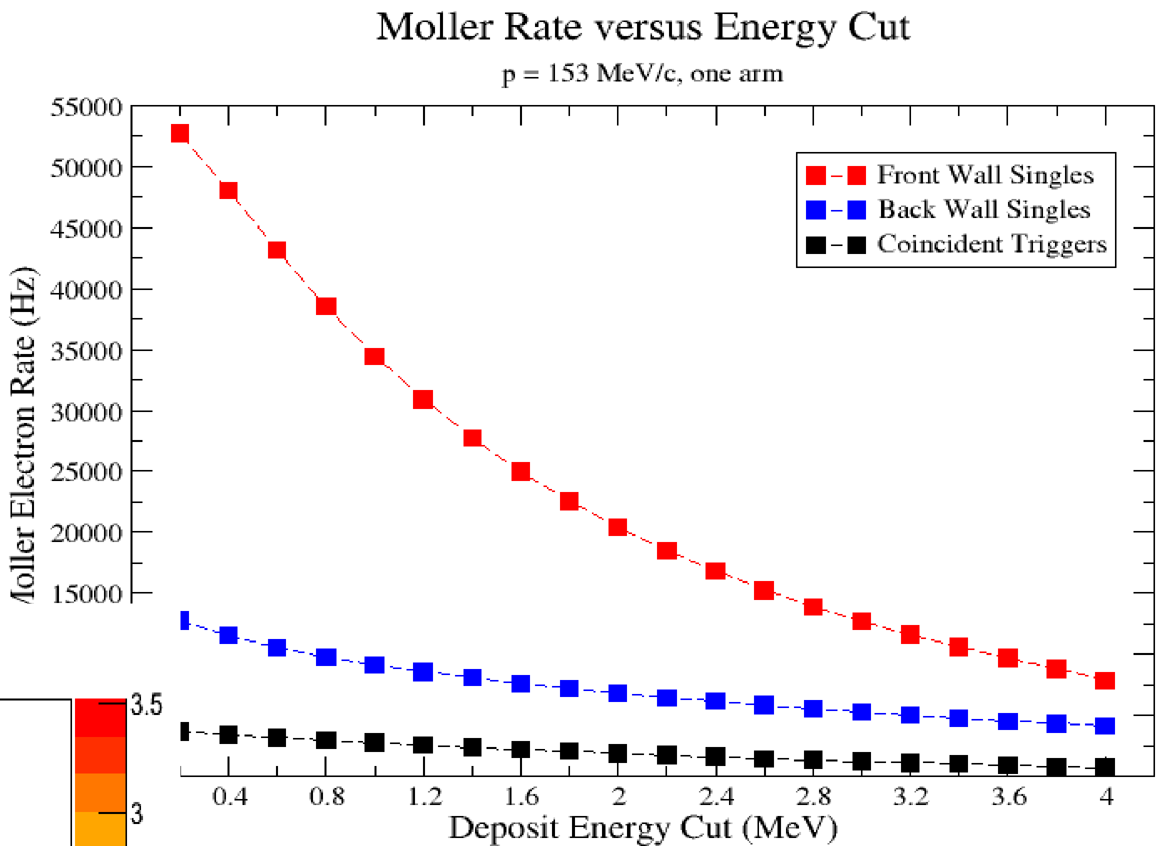
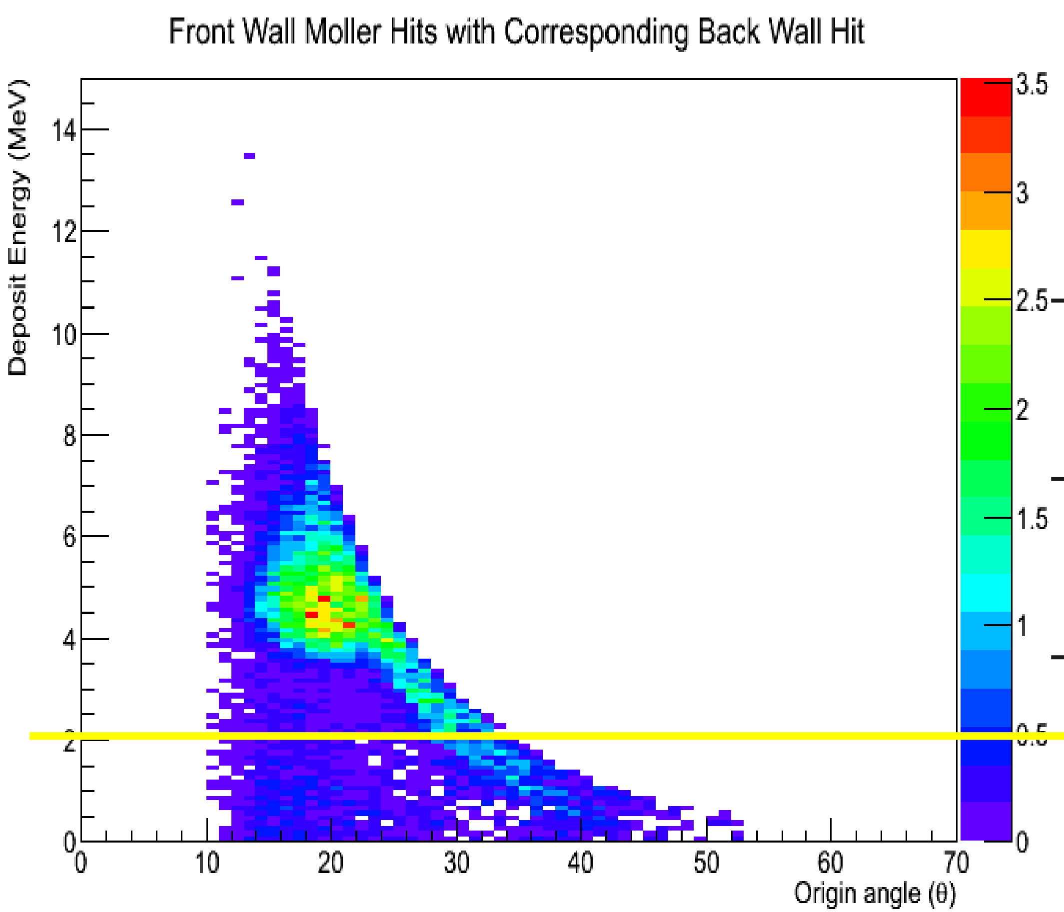




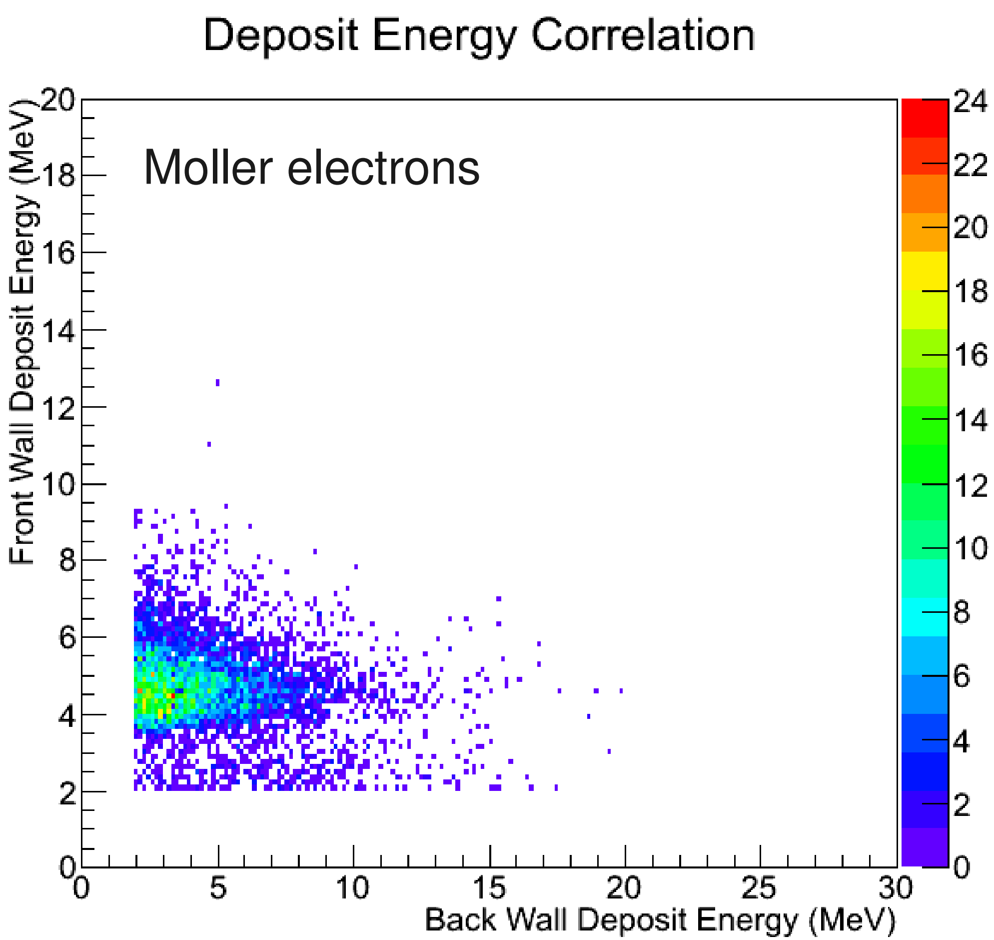
→ With a 2 MeV deposit energy cut, get rid of larger angle events

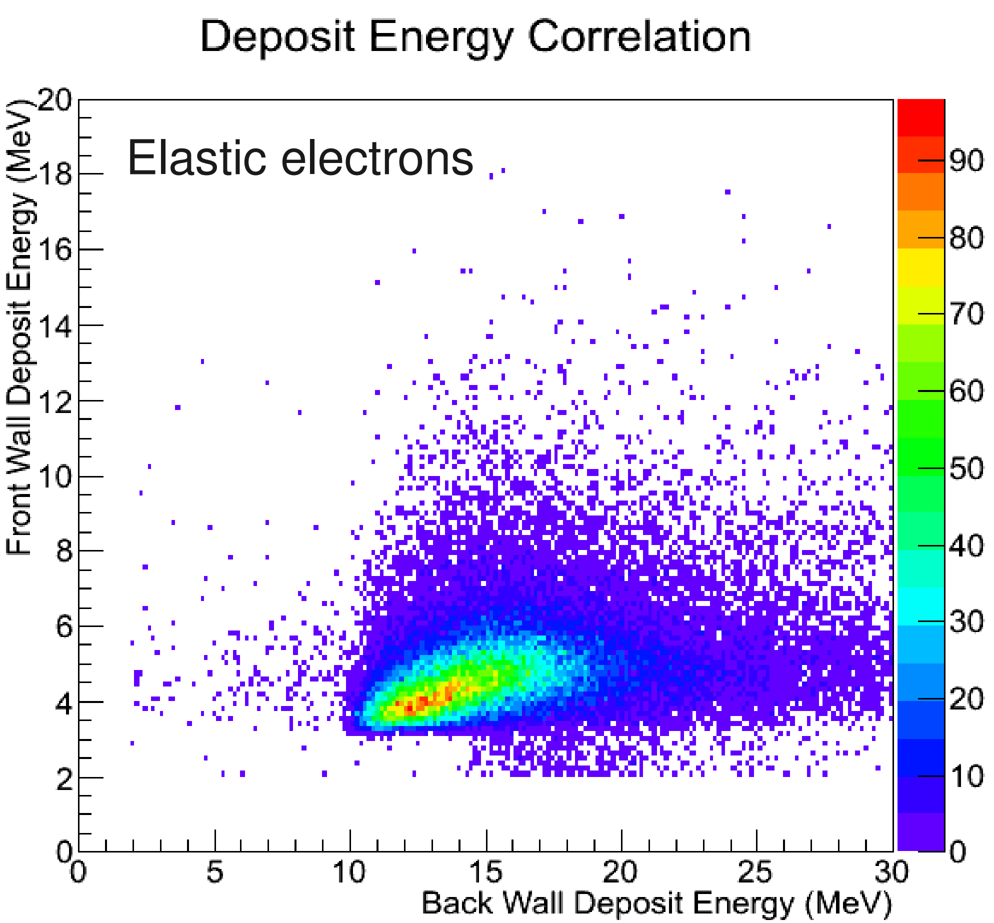
→ With back wall coincidence, significantly reduce rate, reduce theta even more

→ Remaining events:
- → compare front wall/back wall energy dep
- → Drop lowest angle bin?
- → Veto with coincident forward-going e?

Electron Backgrounds:

e.g. Møller backgrouds: → compare front wall/back wall energy dep





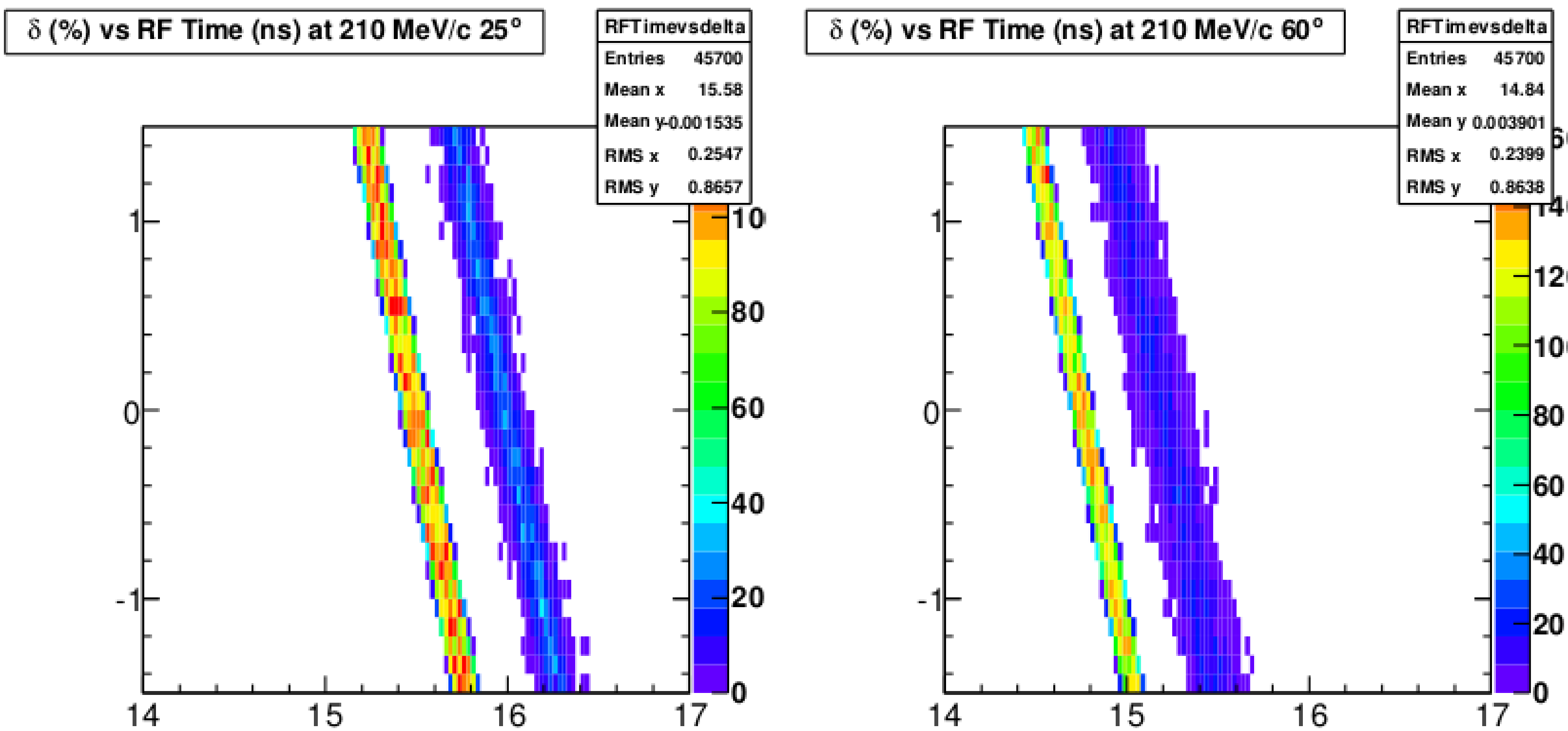
Elastic electrons deposit more energy in back wall

Muon Backgrounds:

→ Decays can be suppressed with track reconstruction, unless the decay is within ~ +- 10 cm of the target

→ 15% of the previously quoted pion rate comes from this region

→ Decays in the target will have a slightly different RF time than elastic μp



Right band:

μp elastic events

Left band:

μ decays in target

Other low-energy Backgrounds:

→ More recent simulations have included GEM detectors, scattering chamber, and wire chambers
→ Can look at very rough “Reconstructed Z Vertex” plots

Caveat: very preliminary, designs of scattering chamber and shielding are in progress, backgrounds only in these plots (no elastics), **work in progress!**

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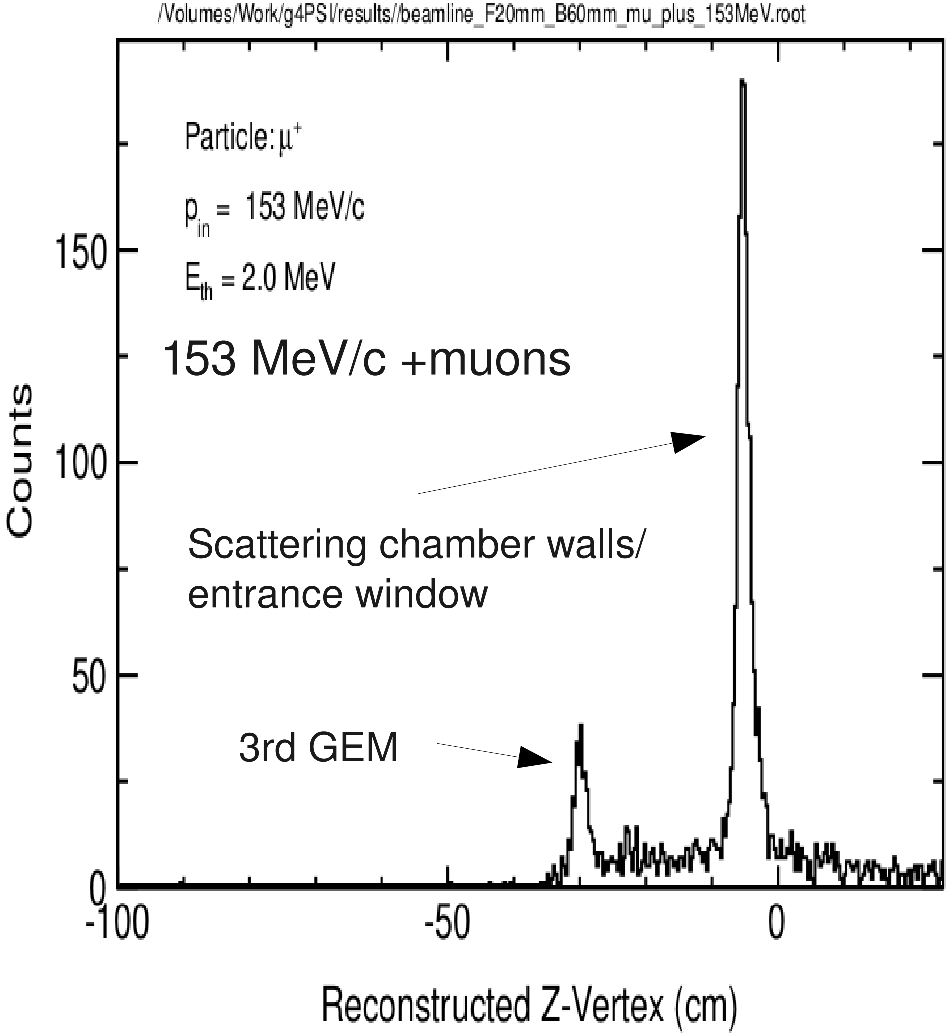
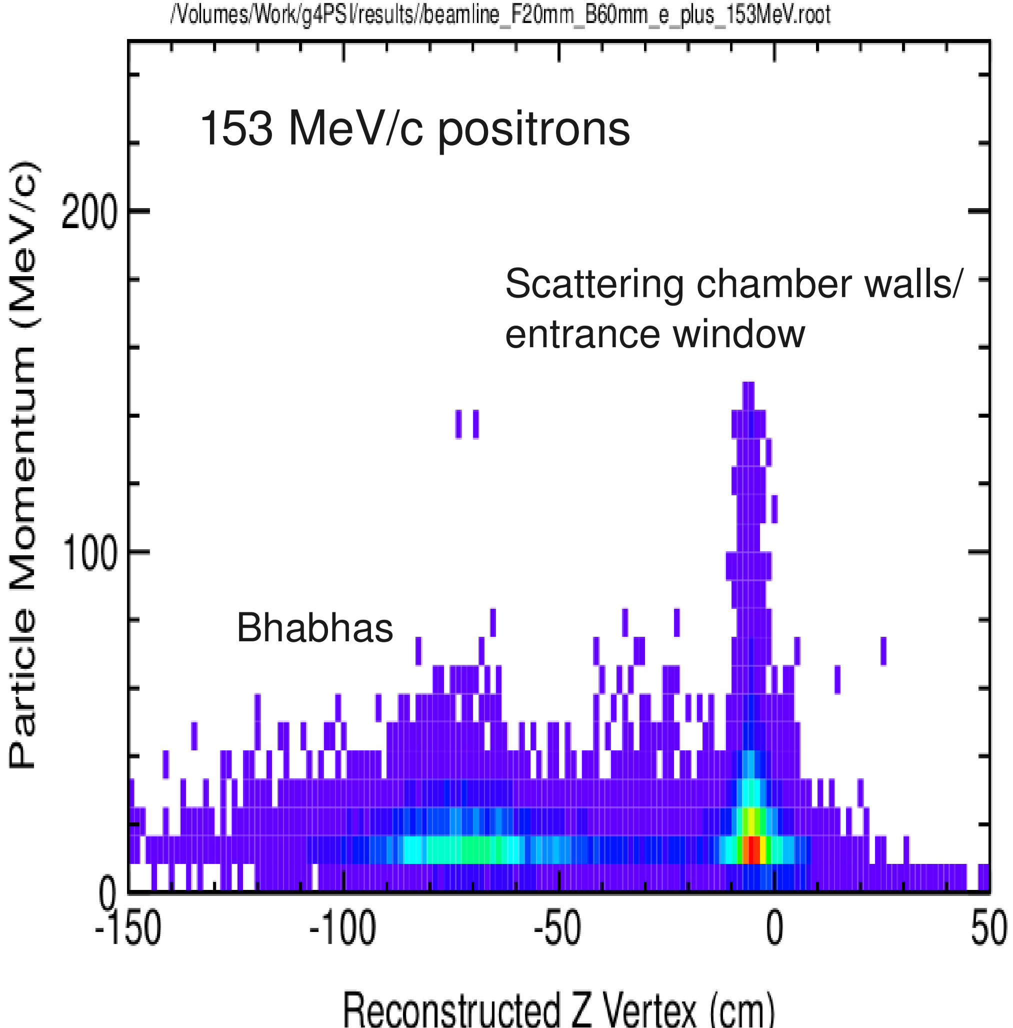
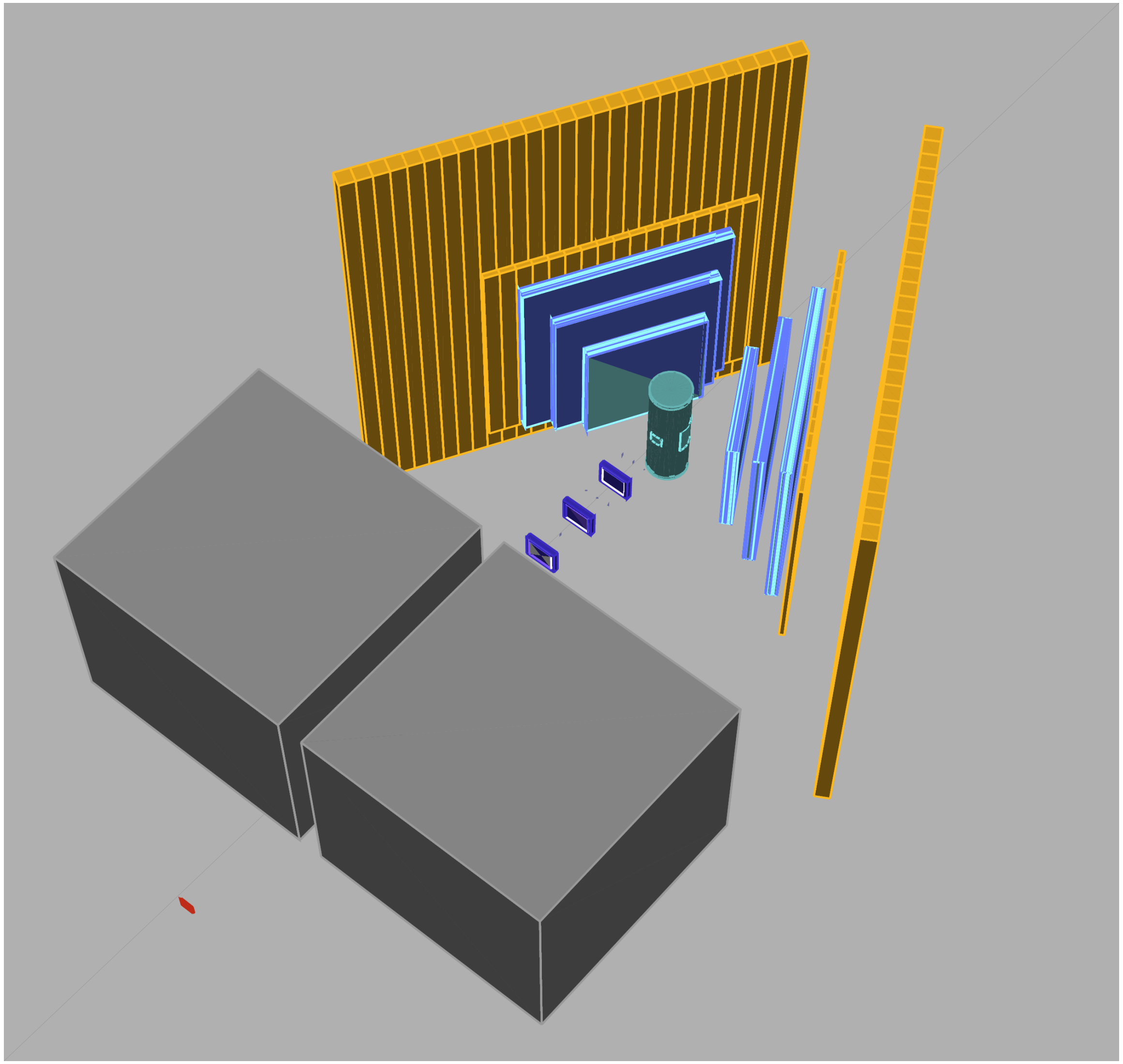




Backgrounds summary:



→ Shielding simulations completed for studying concrete needs to remove upstream decays

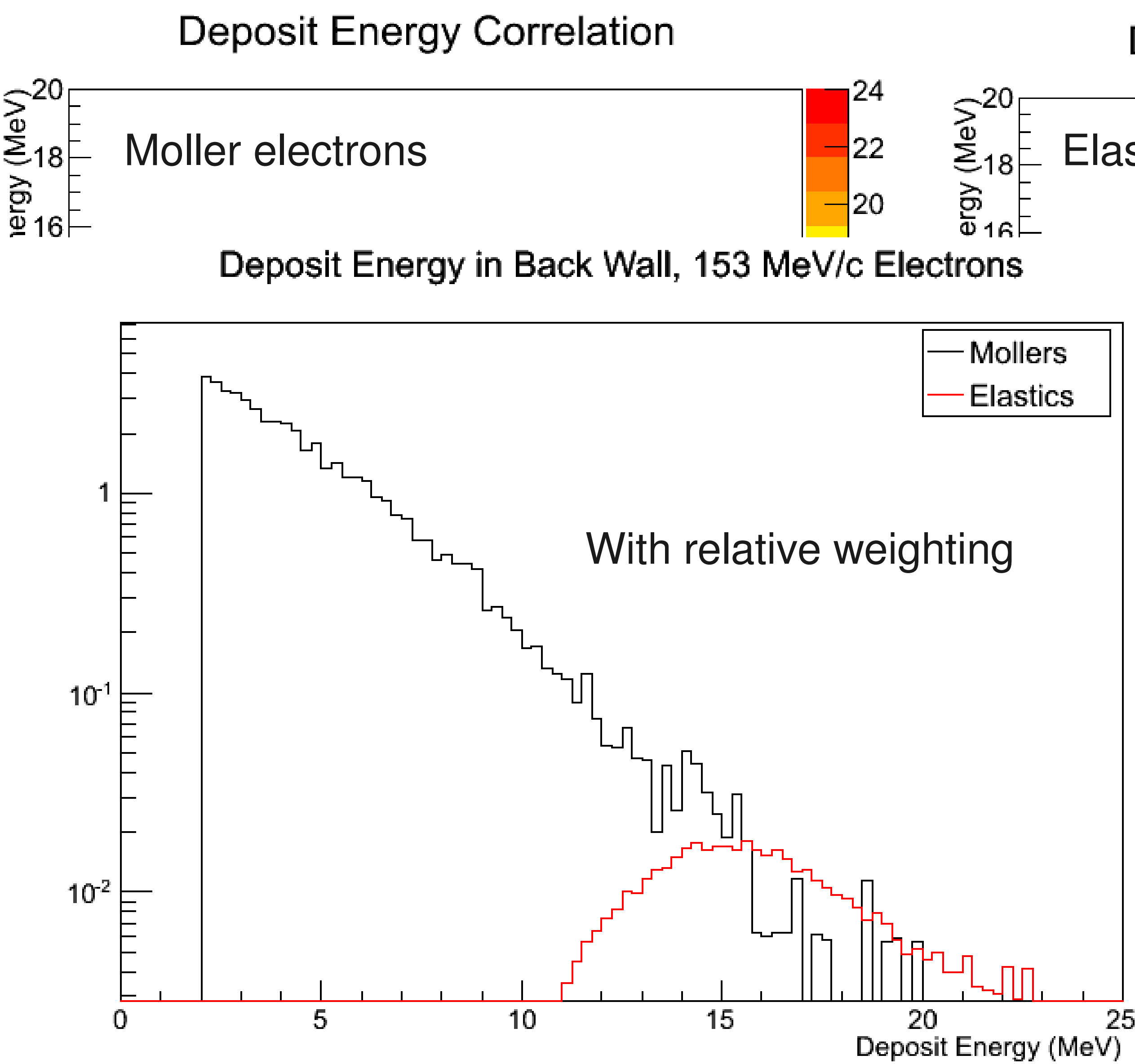
→ Decays closer to the target can be removed through tracking
  → muon decays from the target can be separated by RF time

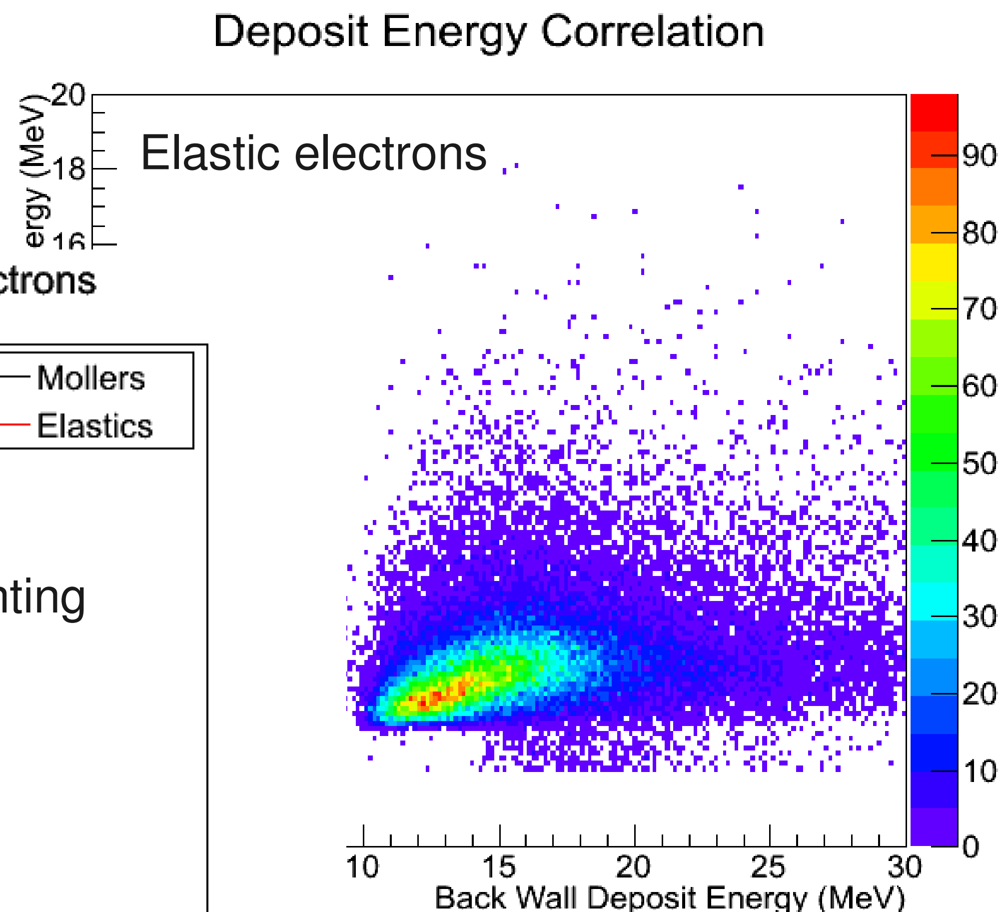
→ Low-energy backgrounds from the target will deposit less energy in the back wall scintillators

→ Work is continuing to make the Geant4 simulation more realistic and study further shielding needs
  → shielding to side of GEMs
  → collimation after the GEMs
  → lead bricks between GEMs
  → optimizing the scattering chamber design

Electron Backgrounds:

e.g. Møller backgrouds: → compare front wall/back wall energy dep





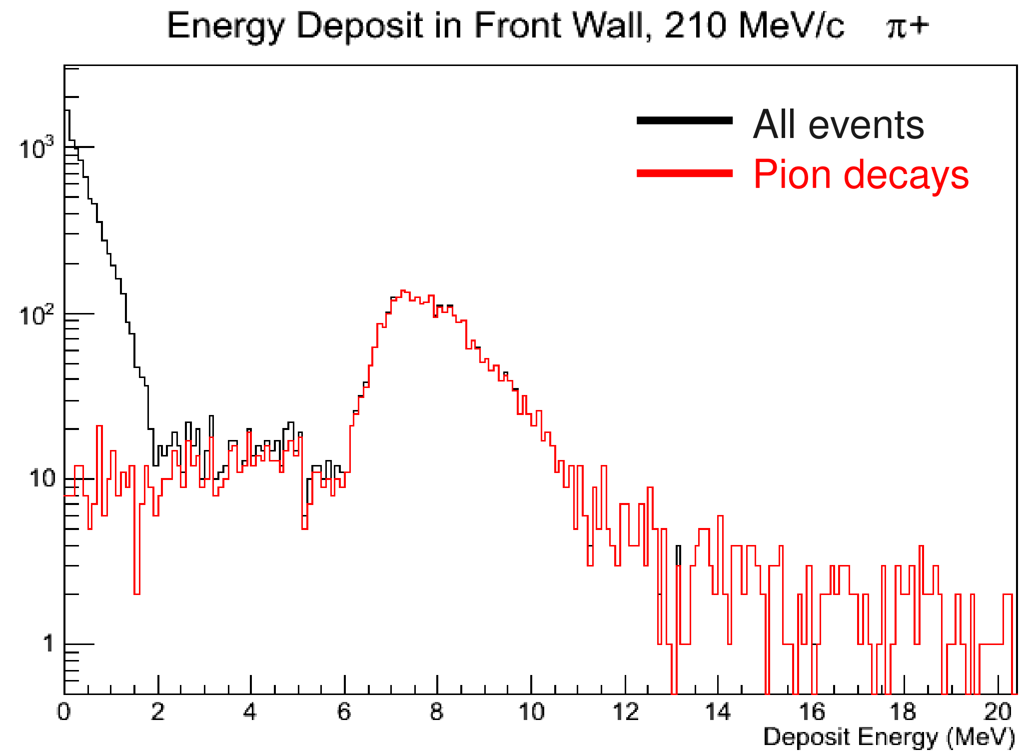
eposit more energy in back wall

Pion Backgrounds:

Comment: Simulation not complete

Energy deposit in front wall:

→ peak ~ 8 MeV
→ low-energy tail



Z origin of front wall hits:

→ sharp peak at target
→ events which generate a large enough signal are primarily pion decays from upstream, will not point back to the target